ENGINEERS AUSTRALIA

Western Australia Division

ENGINEERS
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NOMINATION OF

DESIGN & CONSTRUCTION OF MT HENRY BRIDGE

FOR AN

ENGINEERING HERITAGE MARKER (EHM)

PREPARED BY ENGINEERING HERITAGE WESTERN AUSTRALIA

SEPTEMBER 2023

CONTENTS

1. GENERAL

Name of Item:	**Mt Henry Bridge**
Description of Item:	Two overlapping, side-by-side, prestressed concrete, 9 span road and rail bridges
Engineering Heritage theme(s):	Bridges
State/Territory Heritage listing:	Western Australia
Type of heritage:	Immovable|Tangible & Immovable|Intangible
Relevant Dates:	Bridge 1: Started 1979, completed 1982 Bridge 2: Started 2005, completed 2007
Location:	Canning River, Mt Pleasant, Perth
Coordinates (if known)	32°02′00″S 115°51′31″E
Local Government Area:	City of South Perth and City of Melville
Owner:	Main Roads Western Australia
Marker Type sought:	Engineering Heritage Marker

2. DESCRIPTION

The Mt Henry Bridge is the longest combined road and rail bridge in Western Australia and forms a vital link in the Kwinana Freeway from the Perth CBD to the southern residential suburbs, the industrial and naval precincts of Kwinana and Cockburn Sound. It is also the gateway to the tourist areas and wine growing region of the southwest of Western Australia.

The bridge now comprises two separate side-by-side structures, which overlap without touching, designed and built in separate eras over 20 years apart. Both are conventional post-tensioned concrete box structures, but designed and built by contrastingly and innovative different methods unique to their eras. The first bridge was one of the last major concrete bridges in Australia built using the falsework-supported segmental box construction technique. This involved using temporary falsework supported on the permanent pile caps and by a cable-stayed tower which also served to handle the individual 110 tonne segments. The use of expensive mid-span temporary support piers was thus able to be avoided.

The second bridge was designed and built using the incremental launch technique. For this method, the use of temporary piers could not be avoided, but their size and cost were minimised to carry mainly vertical loading with complex bracing to cater for lateral loads.

The original bridge was also strengthened to upgrade its capacity to support rail traffic.

3. OWNER'S LETTER OF SUPPORT

mainroads
WESTERN AUSTRALIA

Enquiries: Jeff Oo on 9323 4416 / 0419 042 464
Our Ref: 03/3899

Chairperson Mr P Beor
Engineering Heritage Western Australia
Level 10 Allendale Square
77 St George's Terrace
Perth WA 6000

Dear Mr Beor

ENGINEERING HERITAGE RECOGNITION – MOUNT HENRY BRIDGE

Thank you for your approach to Main Roads Western Australia, seeking nominations for heritage recognition by Engineering Heritage Australia (EHA).

As you may be aware, in February 2023, Engineering Heritage Western Australia (EHWA) submitted a 'Proposal to Nominate' to EHA for heritage recognition of Mount Henry Bridge, with the final stage of this process to submit the nomination from EHWA to EHA.

As Main Roads is the asset owner of Mount Henry Bridge, please accept this correspondence as confirmation of our Agency's support for the proposed heritage recognition of the bridge, including our forthcoming nomination.

The listing of this vital infrastructure will showcase a suite of Main Roads innovative practices, including construction technique, piling innovation and utilisation of reinforced concrete, which I am confident exemplifies the engineering prowess that was required during its construction.

Moving forward, I would be supportive of a commemorative ceremony, should the nomination be successful.

Should you wish to discuss this nomination in more detail, I nominate our Asset Manager Structures, Mr Jeff Oo, as Main Roads' contact for this initiative. I understand Mr Oo is already in discussions with your panel member, Mr Gerry Hofmann, and encourage these continued discussions moving forward. Mr Oo's details are listed at the top of this correspondence.

I trust this information is of assistance.

Yours sincerely

JOHN ERCEG
MANAGING DIRECTOR MAIN ROADS

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4. SIGNIFICANCE

4.1 Historical and Social Significance

(a) **Importance in the course, or pattern, of the region's history**

The bridges enabled the Kwinana Freeway, the major north-south arterial link to the south of Perth, to be extended to the industrial and naval defence suburbs of Kwinana and Cockburn Sound and the major tourist and wine-growing regions of the south-west of the state.

Also, the bridges were sensitively designed and built, allowing for the retention of a wide strip of foreshore with its good spread of Nuytsia floribunda (Western Australian Christmas Tree) and the large and very old paperbarks in that area.

(b) Strong or special association with the life or works of a person, or group of persons, of importance in a region's history

The original Mt Henry Bridge was the last major bridge in WA designed in-house by Main Roads engineers and was built by WA's oldest private engineering contractor (Clough).

(c) Potential to yield information that will contribute to an understanding of the region's history

The extension of the Kwinana freeway across the Canning River was the trigger for the major development of the industrial and defence precincts of Kwinana, Naval Base and Cockburn Sound.

4.2 Engineering and Technical Significance

(a) Creative and Technical Achievement

The construction of Mt Henry Bridge 1 involved full span-length temporary falsework with a mid-span cable-stayed support system. This large trussed steel tower, supported on the most recently constructed pier and guyed back to a previous pier, supported the falsework with heavy guy wires and also incorporated a winching system that was used to lift and move each precast concrete segment from travelling bogies on the previously completed deck down onto the falsework where they were moved into their final position by self-powered hydraulic bogies. As each span was stressed to form the completed structure and to become self-supporting, the supporting guy wires had to be carefully destressed in sequence to ensure that the bridge did not deflect upwards.

Mt Henry Bridge 2 was designed to create a widened structure to accommodate two additional railway tracks for the new southern suburbs railway. Rather than just widening the original bridge, the innovative solution of building an adjacent, but separate, structure was conceived.

The construction of Mt Henry Bridge 2 was undertaken by incremental launching, made more complex by the need to construct the bridge so as to overlap (but not touch) the original bridge as well as being able to minimise the need for complex and expensive mid-span temporary piers. The bridges do not touch as the two structures have sufficient deck areas to cater for the required road, rail and pedestrian traffic and the fact that the second bridge was incrementally launched adjacent to the original fixed structure of the first bridge.

At the same time, the original bridge was strengthened to support the additional loading imposed by the railway system and this involved an extremely complex and technically challenging system of both analysis of the existing bridge's design and how to incorporate and construct additional strengthening elements. These strengthening elements consisted of additional internal vertical "stress blocks", tension ties to provide alternative load paths at the diaphragms, extra flexural concrete and exposed post-tensioning with "blister" connections to strengthen the bottom flanges.

(b) Demonstrating the principal characteristics of an aspect of the development of engineering practice

Both bridges were constructed in marine environments that provided large depths of very soft alluvial materials over the underlying suitable supporting base material. This necessitated the development of two (one for each bridge) deep piling solutions that had not been used previously.

For Mt Henry Bridge 1, a composite pile system was developed, incorporating a prestressed concrete upper section (in order to carry the large bending moments through the soft upper soil layers) and a rolled steel non-displacement section for the lower part that was able to penetrate-to-fixity in the underlying basement support strata.

Whilst the above solution was successful, it did require the use of very heavy and substantial plant and equipment. Therefore, for the next iteration on Mt Henry Bridge 2, an alternative and simplified piled solution was adopted, whereby open ended steel tubes were utilised with an internal "doughnut" ring at a predetermined level, allowing the lower (non-displacement) section to be driven to fixity within the founding strata and the upper section to be filled with a reinforced concrete core to resist the bending moments.

Also, the bridge design introduced, for the first time in Western Australia, the novel concept of cantilevered pedestrian walkways and cycleways on the

bottom flange, on each side, thus ensuring complete separation of vehicle and pedestrian traffic.

(c) Uncommon or rare aspects of the development of engineering practice

The use of the cable-stayed falsework system to construct Mt Henry Bridge 1 had never previously been used in Australia and has never been used again since.

No other incrementally-launched prestressed concrete bridge has ever been constructed in Australia to integrate and overlap (but not touch) an adjacent "parent" bridge.

(d) Yielding new or further substantial scientific and/or archaeological information; and/or is an important benchmark or reference site or type

Mt Henry Bridge 1 was one of the last post-tensioned concrete box bridges built in Australia before the widespread advent of incremental launching technology. As such, it remains as a lasting example of a bridge building technique that is no longer used.

The widening of the original bridge was achieved by building Mt Henry Bridge 2. This resulted in locating the new southern suburbs railway lines on the original Mt Henry Bridge 1, thereby imposing greatly increased loadings on the 20-year old structure. The engineering challenges involved in the strengthening of the original bridge and the technical and constructability challenges learnt and overcome to achieve this will remain as excellent background knowledge for future bridge strengthening exercises that can be expected to become more prevalent in the future.

5. SUMMARY STATEMENT OF SIGNIFICANCE

The two components of Mt Henry Bridge are each significant projects that highlight the evolution of bridge design and building technologies and know-how that existed in two different eras, over 20 years apart. As a minimum, they serve as a comparison and reminder of how far engineering technology has advanced in that period, but also as examples of innovative and creative methods that were used to design and build each bridge to overcome the unique challenges facing the design and construction engineers at those times.

Both bridges employed innovative solutions for their respective designs and construction methods, both with the complex foundation challenges present as well as the construction of their superstructures. Valuable lessons learnt on each bridge will serve as the basis for suture engineering solutions in a wide range of different projects and environments.

6. HISTORY

The Mount Henry Bridge caries the Kwinana Freeway and Mandurah railway line over the Canning River in Perth, approximately 10 kilometres south of the Perth central business district. At 660 metres long, the Bridge represents the longest road bridge in Western Australia. The Bridge spans the river between the Mount Henry Peninsula and the suburb of Mount Pleasant.

The north-south freeway system, which provides for by-passing the Perth central business district, was planned by Professor Gordon Stephenson and Mr John Alastair Hepburn in 1955 as part of a plan to guide the long-term development of post-war Perth. Following the completion in 1959 of the Narrows Bridge, which connects the north and south banks of the Swan River, and which had been planned independently of the Stephenson-Hepburn Plan, the remainder of the Freeway plan was adopted by the WA State Parliament in 1963.

In 1974, the (then) Metropolitan Region Planning Authority (MRPA) held public hearings in which eighteen alternative routes were examined. Numerous amendments were made to the plan on a number of occasions, brought about by changing demands and following further studies. Some of these included sinking the freeway into a tunnel south of Canning Bridge in order to avoid ecological damage to the pristine Canning River.

Ultimately, in 1975, Parliament approved the MRPA's recommendation and the Metropolitan Region Scheme was amended to show the crossing on the eastern side at Mount Henry. Stage 1 of the freeway extension, now confirmed as The Kwinana Freeway, resulted in the completion of the Canning Interchange in 1979. The second stage of the project involved the construction of the Mount Henry Bridge 1 and the extension of the freeway to South Street and opened in April 1982.

Mount Henry Bridge 1 was sensitively designed, and was constructed in such a way as to retain the foreshores of Mount Henry and Mount Pleasant. The bridge was nearly twice the length of the Narrows Bridge, with separate pedestrian and cycle paths cantilevered below the main traffic lanes of the bridge. The official opening took place on 9 May 1982 by WA Premier Ray O'Connor.

The winning construction tender by the Clough Group was based on a novel and innovative system of using a temporary cable-stayed tower to provide mid-span support of the temporary falsework during the erection of each span while also doubling up as a gantry crane to lift the 110 tonne precast units into position. Conceived by Clough and designed by the Swiss consulting engineers Cepas Plan Ltd of Zurich, the falsework system won the Western Australia Division of Institution of Engineers Australia Engineering Excellence Award for 1981.

The falsework truss was moved from span to span by two barges, one of which was self-propelled, and being the same barges that were used to construct the river piling, the pile caps and the piers.

In 2005, further construction work commenced on Mount Henry Bridge 2 as part of the widening of the Kwinana Freeway and to accommodate a two-way railway line. This was part of a new railway system located in the median between the opposing traffic lanes of the Kwinana Freeway; and extending from the Perth central business district to Mandurah. The design brief for the design-and construct contract was to widen the existing Mt Henry Bridge 1, however after numerous studies and options were explored within the constraints of the road reserve boundaries, the solution finally adopted was to build an adjacent second bridge whose outer edge landed right on the road reserve boundary. The new 15 metre wide bridge was built to the west of the original Mount Henry Bridge 1 with exact matching spans. Mt Henry Bridge 2 is a single cell box structure whereas the original bridge was a two-cell box structure. It was designed to carry the three northbound lanes of traffic, a break-down lane and a cycle and walking path, while Mt Henry Bridge 1 was to carry the three southbound lanes and both sets of railway tracks. The two bridges overlap but do not touch, appearing as one continuous structure. The railway is accommodated on the western side of mt Henry Bridge 1.

Mt Henry Bridge 2 was constructed by incremental launching from the south abutment but this time, the use of temporary mid-span piers could not be avoided. The detailed design of these mid-span temporary piers was an extremely complex engineering exercise, influenced by the need to minimise the number of temporary piles but still provide the level of horizontal restraint needed during the launching process. This was achieved by bracing the temporary piers against the existing bridge with a flexible lateral brace and longitudinally with prestressing cables running between adjacent permanent piers. The sequential stressing of these cables and setting and measurements of vertical displacements of the temporary piers was very carefully monitored by the design and construction engineers.

Whilst the shapes of the piers of the second bridge may look different to the piers on the first bridge, they are in fact the same shape, but reversed left-to-right in order to geometrically fit in the required space – wide enough for the pile caps and narrow enough for the bridge deck. Refer to the schematic diagram that illustrates this concept in Section 9, Gallery.

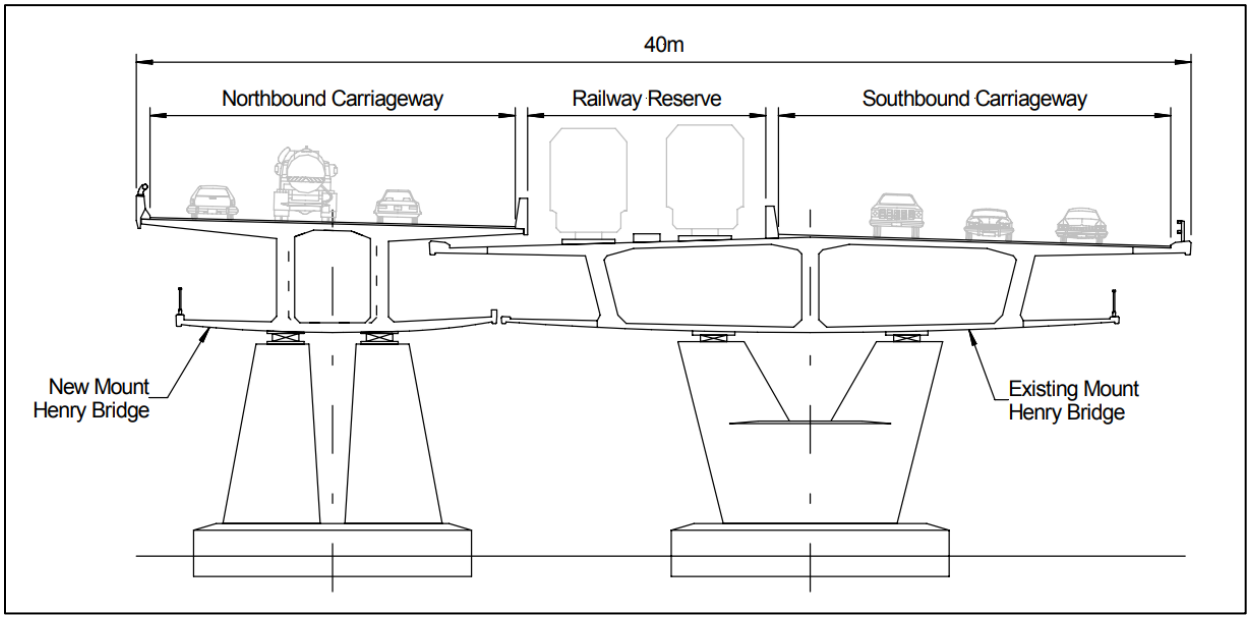
The new traffic bridge was opened to traffic in January 2006 and the southern suburbs railway commenced operation in December 2007.

7. **GALLERY**

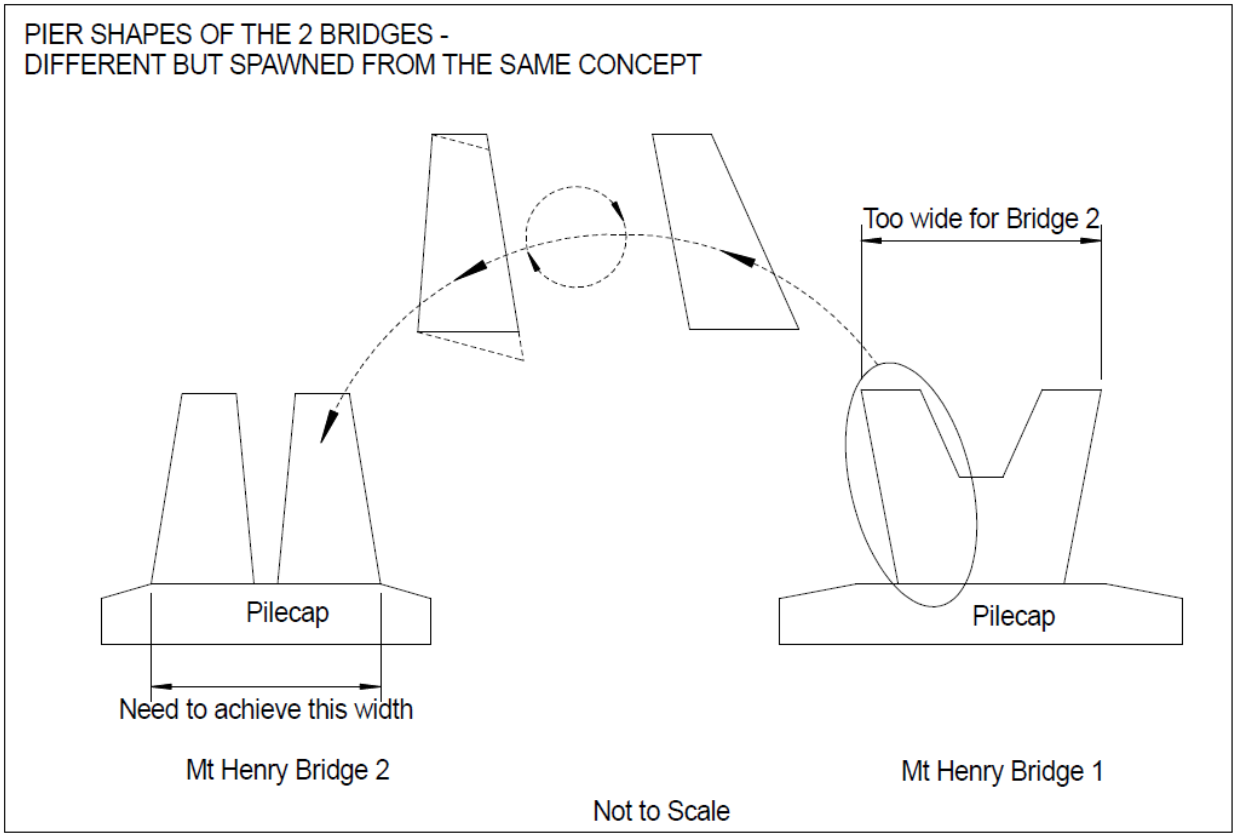
Mt Henry Bridge 1 under construction

Mt Henry Bridge 2 under construction

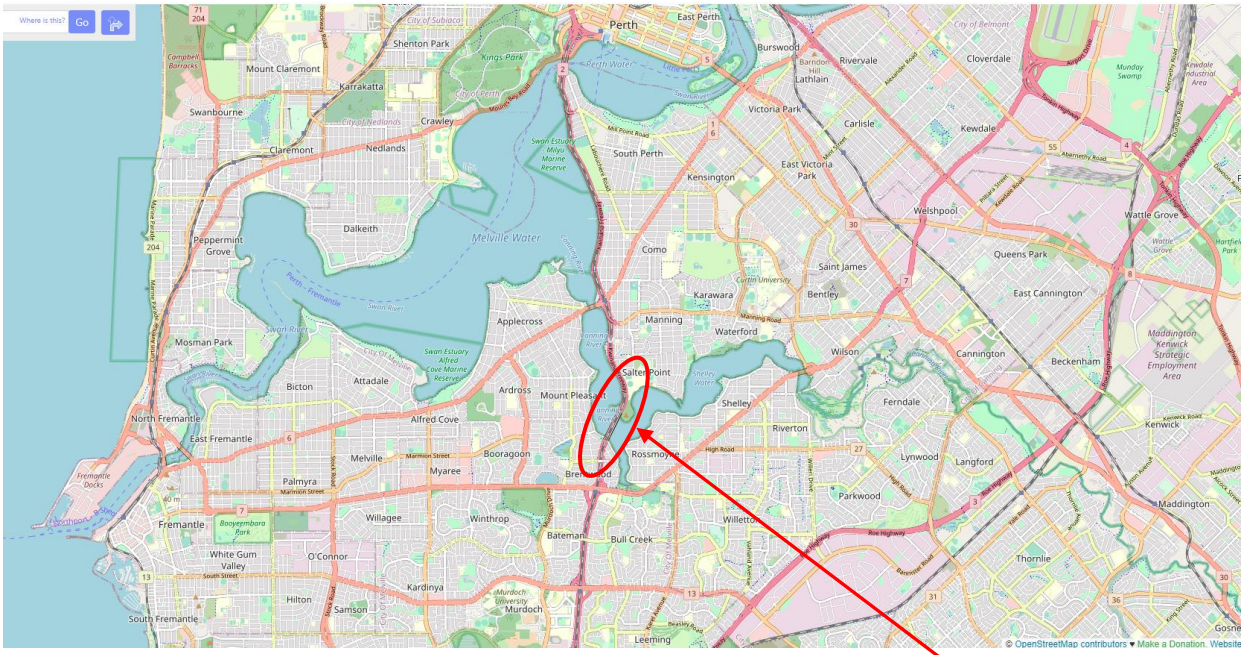
The completed Mt Henry Bridge(s)



Cross Section showing how the two Mt Henry Bridge(s) interact without touching



8. LOCATION MAP



https://www.openstreetmap.org/#map=13/-32.0149/115.8527

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"*Legs of Steel*", The driving of the piled foundations for the Mount Henry Bridge, Perth, Western Australia, video production by Clough Engineering, 1982.

"*Incremental Launching Challenges on Mount Henry Bridge*", Noel Wenham, Senior Structural Design Engineer, Wyche Consulting

"*Sustainable Design Commendation, The New Mt Henry Bridge*", presented to Parry and Rosenthal, Architects by Cement Concrete & Aggregates, Australia and C&CAA Domain Awards, 2008.

"*Mount Henry Bridge, Perth, Western Australia"*, Clough Engineering Group, submission for the 1982 AFCC Construction Achievement Award.

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